

PROCESS FOR MANUFACTURING A WIRING BOARD

## BACKGROUND OF THE INVENTION

## 5 1. Field of the Invention

The present invention relates to a process for manufacturing a wiring board and, more particularly, to a process for manufacturing a circuit board in which a first wiring pattern formed on a first surface of a substrate made of resin as a basic material is electrically connected to a second wiring pattern formed on a second surface opposite to the first surface by means of vias penetrating through the substrate.

## 15 2. Description of the Related art

One of the known processes for manufacturing a wiring board on which semiconductor elements, or other electronic elements, is mounted are called a "damascene" method.

An example of such "damascene" method is shown in Figs. 10(a) to 10(e). Fig. 10(a) is a cross-sectional view of a wiring board 100 on which wiring patterns 140a are formed. The wiring board 100 is made of resin as a basic material. The wiring pattern 140a can be formed by coating photo-resist on the respective surfaces of the resin plate on which copper foils are attached beforehand, light-exposing thereto in accordance with a predetermined pattern for forming the wiring patterns 140a, developing the same to form a resist pattern, and etching the exposed portions of the copper foil using a masking of the resist pattern to remove the exposed area.

The wiring patterns 100a formed on the respective surfaces of the wiring board 100 are electrically connected to each other by means of through holes 120. The through holes 120 are formed by forming via holes by drilling the wiring board 100, and then forming a thin metal film on the inner wall of the via holes by electroless-plating, and then forming a

conductor layer on the inner wall of the via holes by electro-plating using the thin metal film as a power-supply layer.

5 In addition, on the respective surfaces 160a and 160b of the wiring board 100 shown in Figs. 10(a) resin layers 160a and 160b are formed by coating the same with a resin, such as a polyimide or an epoxy resin, as shown in Fig. 10(b).

10 As shown in Fig. 10(c), via recesses 130 and wiring pattern recesses 132 are formed on the resin layers 160a and 160b by irradiating laser light, such as, CO<sub>2</sub> laser or excimer laser light.

15 The wiring board 100 thus having the resin layers 160a and 160b formed with the via recesses 130 and wiring pattern recesses 132 is now processed as follows. As shown in Fig. 10(d), after a metal thin film is formed on the inner wall of the via recesses 130 and wiring pattern recesses 132 and on the surface of the resin layer 160a by electroless-plating of copper or the other, 20 an electro-plating is applied to fill the via recesses 130 and wiring pattern recesses 132 with plated metal 134 using the metal thin film as a power-supply layer. In this case, the surface of the resin layer 160a is also coated with a plated metal 134.

25 Therefore, the plated metal 134 covering the surface of the resin layer 160a is removed by polishing, as shown in Fig. 10(e), and thus the surface of the resin layer 160a is exposed. By such a polishing the wiring patterns 150a consisting of vias 120 formed with the 30 filled plated metal 134 in the via recesses 130 and plated metal 134 filled in the wiring pattern 132 recesses are exposed on the same surface as the surface of the resin layer 160a, so that the wiring patterns 150a are formed on the surface of the resin layer 160a.

35 According to the "damascene" method as mentioned above, very fine and dense wiring patterns can be obtained as compared with a conventional wiring board

which is made by a "sub-tractive" method or a "semi-additive" method as known in the prior art.

However, the wiring patterns formed on the respective surfaces of the wiring board 100 are electrically connected with each other by means of through holes 120. Since the wiring pattern and through holes 120 are formed respectively by the separate processes, it is difficult to reduce the production cost of the wiring board 100.

Also, since the via recesses 130 and wiring pattern recesses 132 of the resin layers 160a and 160 are formed by irradiating laser light, such as CO<sub>2</sub> laser or excimer laser light, a facility for irradiating laser light is necessary. Also, since the depth of the via recesses 130 is different from that of the wiring pattern recesses 132, it is necessary to precisely control the intense or irradiation time of laser beam. Thus, the production cost of the obtained wiring board is high.

#### SUMMARY OF THE INVENTION

An object of the present invention is to provide a process for manufacturing a wiring board capable of easily forming via recesses for filling with plating metal and of reducing the production cost of the wiring board.

According to the present invention, there is provided a process for manufacturing a wiring board, said process comprising the following steps of: making a resin plate having wiring pattern recesses and via through holes; coating all of the surfaces of the resin plate including inner walls of said wiring pattern recesses and via through holes with a metal film; applying an electroplating using said metal film as a power-supply layer to fill a plated metal into said wiring pattern recesses and via through holes; and removing said metal film formed on said resin plate except for the inner walls of said wiring pattern recesses and via through holes, so that wiring pattern and vias are exposed on a surface the same

as that of said resin plate.

The resin plate is formed by a press-forming process. Otherwise, the resin plate can be formed by an injection molding process.

5       The above mentioned process further comprises the following steps of: forming pads on one of surfaces of the wiring board to which external connecting terminals are to be attached.

10       The above mentioned process further comprises the following steps of: using said wiring board as a core substrate; and forming wiring patterns on the respective surface of the core substrate by means of resin layers to obtain a multi-layer wiring board.

15       According to another aspect of the present invention, there is provided a process for manufacturing a multi-layer wiring board, said process comprising:

20       (a) manufacturing a core substrate comprising the steps of: making a resin plate having wiring pattern recesses and via through holes; coating all of the surfaces of the resin plate including inner walls of said wiring pattern recesses and via through holes with a metal film; applying an electro-plating using said metal film as a power supply layer to fill a plated metal into said wiring pattern recesses and via through holes; and  
25       removing said metal film formed on said resin plate except for the inner walls of said wiring pattern recesses and via through holes, so that wiring pattern and vias are exposed on a surface same as that of said resin plate; and

30       (b) forming resin layers on respective surfaces of said core substrate so that said resin layers includes wiring pattern recesses and via through holes;

35       (c) coating all of surfaces of said resin layers including inner walls of said wiring pattern recesses and via through holes with a metal film;

      (d) applying an electro-plating using said metal film as a power supply layer to fill a plated metal into

said wiring pattern recesses and via through holes; and  
(e) removing said metal film attached to said resin  
layer except for the inner walls of said wiring pattern  
recesses and via through holes, so that wiring pattern  
and vias are exposed on a surface same as that of said  
resin plate.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1(a) to 1(e) are cross-sectional views  
explaining an embodiment of a process for manufacturing a  
wiring board process according to this invention;

Figure 2 is a partial cross-sectional view of an  
embodiment of a semiconductor package obtained by a  
process as shown in Figs. 1(a) to 1(e);

Figures 3(a) to 3(d) are views explaining an  
embodiment of a process for manufacturing a multi-layer  
wiring board using a wiring board obtained by the process  
shown in Figs. 1(a) to 1(e);

Figure 4 is a partial view of an embodiment of a  
multi-layer wiring board obtained by a process as shown  
in Figs. 3(a) to 3(d);

Figures 5(a) to 5(e) are views explaining another  
embodiment of a process for manufacturing a multi-layer  
wiring board using a wiring board obtained by the process  
shown in Figs. 1(a) to 1(e);

Figures 6(a) and 6(b) are views explaining another  
embodiment of a process for manufacturing a wiring board  
of this invention;

Figures 7(a) and 7(b) are views explaining still  
another embodiment of a process for manufacturing a  
multi-layer wiring board using a wiring board obtained by  
the process shown in Figs. 1(a) to 1(e);

Figures 8(a) to 8(c) are views explaining still  
another embodiment of a process for manufacturing a  
wiring board of this invention;

Figure 9 is a partial cross-sectional view of an  
embodiment of a semiconductor package obtained by a  
process as shown in Figs. 8(a) and 8(b); and

Figures 10(a) to 10(e) are views explaining a process for manufacturing a wiring board process conventionally known in the prior art.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

5 Fig. 1(a) to 1(e) explain an embodiment of a process for manufacturing a wiring board process according to this invention, in which the wiring board is produced by a press-forming a processing resin plate. First, the processing resin plate 10 as shown in Fig (a) is  
10 subjected to press forming by a pair of molds 14a and 14b so that a resin plate 12 is obtained. The resin plate 12 is formed with the wiring pattern recesses 16, 16, .. and the via through holes 18, 18, .. by the pair of molds 14a and 14b.

15 Either of a thermoplastic resin or a thermosetting resin can be used as the processing resin plate 10. In case of using a thermoplastic resin, it is preferable that the processing resin plate 10 is softened by heating so that a press forming can be smoothly carried out. In  
20 case of using a thermosetting resin, it is preferable to use such a processing resin plate which is softened so as to smoothly carrying out the press forming process.

A thin metal film 20 is formed all over the surface including the inner walls of the via through holes 18,  
25 18, .. and the wiring pattern recesses 16, 16, .. Although the metal film 20 can be formed by vapor deposition or sputtering, it is preferable to form such a thin metal film 20, made of such as a copper, by electroless-plating.

30 An electro-plating is applied to the resin plate 12 covered with the thin metal plate 20 using the thin metal plate 20 as a power supply layer, so that the via through holes 18, 18, .. and the wiring pattern recesses 16, 16, .. are filled with the plated metal to form a metal layer  
35 22. The metal layer 22 is also formed on the surface of the resin plate 10 where the via through holes 18 and the wiring pattern recesses 16 are not formed. The metal

layer 22 serves to electrically connect the vias and the wiring patterns which are formed by filling the via through holes 18 and the wiring pattern recesses 16 with the plated metal.

5           Therefore, the metal layer 22 formed on the resin plate 12, except for the portions of the metal layer 22 formed on the inner walls of the via through holes 18 and the wiring pattern recesses 16, is partially polished to obtain a wiring board 30 in which the surfaces of the  
10       vias 22, 22, .. and the wiring patterns 24, 24, .. are exposed at the same level as the surface of the resin plate 12, as shown in Fig. 1(e).

          As shown in Fig. 1(e), the wiring board 30 is formed by polishing the respective surfaces of the resin plate  
15       12 and thus a semiconductor package, as shown in Fig. 2, on which a semiconductor element 36 can be mounted, can thus be obtained. The semiconductor package shown in Fig. 2 is provided on one of the surfaces of the resin plate 12 with solder balls 34, 34, .. as connecting terminals  
20       which can be connected to electrode terminals of the semiconductor element 36 to be mounted, and on the pads formed on the other surface of the resin plate 12 with solder balls 32, 32, .. as external connecting terminals.

          The respective surfaces of the resin plate 12 are  
25       coated with solder resists 38, 38 except for the solder balls attached to the respective pads.

          The wiring board 30 shown in Fig. 1(e) can be used as a core substrate and therefore multi-layer wiring patterns are formed on the respective surfaces of the  
30       core substrate to obtain a multi-layer wiring board.

          The wiring board 30 in this embodiment can be made by filling the plated metal into via through holes 18 and wiring pattern recesses 16, made by press forming the resin plate 12, to form the vias 26 and wiring patterns  
35       24. Therefore, the via through holes 18 and wiring pattern recesses 16 can be made simultaneously as compared with drilling and thus a multi-layer wiring

board, in which a plurality of the vias 26 are very densely arranged, can be obtained with low cost.

A conventionally known build-up method shown in Fig. 3(a) to 3(d) can also be used to make a multi-layer wiring board using the wiring board 30 as a core substrate. Fig. 3(a) to 3(d) explain a process for forming wiring patterns on one of the surfaces of the wiring board 30. However, it is also possible to simultaneously form such wiring patterns on the other surface of the wiring board 30, although an explanation is omitted.

In this build-up method, after resin layers 40 are formed on the respective surfaces of the wiring board 30 as a core substrate as shown in Fig. 3(a), via recesses 42 are formed by irradiating laser light, such as CO<sub>2</sub> laser or excimer laser light, to the positions of the resin plate 40 to form via recesses 42, as shown in Fig. 3(b). Pad surfaces are exposed on the bottom of the via recesses 42.

Next, as shown in Fig. 3(c), a metal layer 44 having a certain thickness is formed by electro-plating over all of the surfaces of the resin plate 40 including the inner walls of the via recesses 42 using a thin metal film formed by electroless-plating as a power-supply electrode. It is preferable that this metal layer 44 is made of copper.

Then, the metal layer 44 is patterned to form wiring patterns 46 and vias 48, as shown in Fig. 3(d).

Next, a resin layer 40 is also formed on the resin layer 40 provided with the wiring patterns 46 and vias 48, and the steps of Figs. 3(b) to 3(d) are repeated to obtain a multi-layer wiring board as shown in Fig. 4.

The multi-layer wiring board 40 shown in Fig. 4 is also a semiconductor package, on which a semiconductor element 36 can be mounted, wherein the semiconductor package is provided on one of the surfaces of the resin plate 12 with solder balls 34, 34, .. as connecting



terminals which can be connected to electrode terminals of the semiconductor element 36 to be mounted, and on the pads formed on the other surface of the resin plate 12 with solder balls 32, 32, .. as external connecting terminals.

The respective surfaces of the multi-layer wiring board are coated with solder resists 38, 38 except for the solder balls attached to the respective pads.

In the multi-layer wiring board 40 shown in Fig. 4, as the resin layer 40 is again formed on the resin layer 40 formed with the wiring patterns 46 and vias 48 to form wiring patterns 46 and the vias 48, the upper layer of the resin layer 40 for forming the multi-layer wiring board can be easily an uneven surface.

In this connection, as shown in Figs. 5(a) to 5(e), a multi-layer wiring board 40 is formed by press-forming, the surface of the upper, resin layer 40 of the multi-layer wiring board can be made flat. Fig. 5(a) to 5(e) also explain a process for forming wiring patterns on one of the surfaces of the wiring board 30. However, it is also possible to simultaneously form such wiring patterns on the other surface of the wiring board 30, although an explanation is omitted.

In this embodiment, after resin layers 40 are formed on the respective surfaces of the wiring board 30 as shown in Fig. 5(a), via recesses 42, 42, .. and wiring pattern recesses 16, 16, .. are formed by press-forming using a pair of pressing molds 50, 50 (in Figs. 5(a) and 5(b), one of the pressing molds 50, 50 is only shown). There is a possibility that a resin film remain on the bottom of the via recesses 42. Therefore, the resin film remained on the bottom of the via recesses 42 is removed by etching so that the pads are completely exposed on the bottom of the via recesses 42.

Next, as shown in Fig. 5(c), a thin metal film 52 is formed over the all surfaces of the resin layer 40 including the inner walls of the via recesses 42 and

wiring pattern recesses 16 by such as electroless-plating.

In addition, an electro-plating is carried out using the metal film 52 as a power-supply layer, as shown in  
5 Fig. 5(d), to fill the plated metal into the via recesses 42 and wiring pattern recesses 16 to form a metal layer 54 having a certain thickness. It is preferable that this metal layer 54 is made of copper.

The metal film 52 is also formed on the surface of  
10 the resin layer 40 where the via recesses 42 or wiring pattern recesses 16 are not formed. The surfaces of the metal layer 54 corresponding to the via recesses 42 or wiring pattern recesses 16 may be uneven, so that vias and wiring patterns which have been formed by filling  
15 plated metal into via recesses 42 or wiring pattern recesses 16 electrically short-circuit to each other.

Therefore, the metal layer 52 attached to the resin layer 40 is polished except for the inner walls of the via recesses 42, 42, .. and the wiring pattern recesses  
20 16, 16, ..., so that the surfaces of the vias 56, 56, .. and the wiring patterns 24, 24, .. are exposed at the same level as the surface of the resin layer 40.

Although, in the wiring board 30 of the previous embodiments shown in Figs. 1(a) to 5(e), the resin plate  
25 12 in which the wiring pattern recesses 16, 16, .. and via through holes 18, 18, .. are formed by press-forming is used, such a resin plate 12 can also be made by injection molding.

Figs. 6(a) and 6(b) show a method of making a resin  
30 plate 12 by injection molding. In this injection molding, a pair of molds 60a and 60b having projections for forming wiring pattern recesses 16 and projections 62 for forming via through holes 18 is used. The pair of molds 60a and 60b can be made by a known electric-forging  
35 method.

Next, as shown in Fig. 6(b), after the pair of molds 60a and 60b are closed, a resin 66 is injected into the

cavity defined in the pair of molds 60a and 60b. The resin may either be thermoplastic resin or thermosetting resin which have fluidity to easily flow through the narrow gaps defined by the projections 62 and 64 in the cavity.

However, if the resin 66 is a thermosetting resin, it is necessary to harden the resin after it is filled in the cavity by heating the same. Also, if the resin 66 is a thermoplastic resin, it is necessary to solidify the resin after it is filled in the cavity by cooling the same.

After the resin 66 in the cavity is hardened or solidified, the pair of molds 60a and 60b are opened and thus a resin plate as shown in Fig. 1(b) can be obtained.

Thereafter, a wiring board 30 can be obtained using a resin plate 12 by the steps as shown in Figs. 1(a) to 1(e).

As shown in Figs. 7(a) and 7(b), a multi-layer wiring board can be obtained by using such an injection molding. Fig. 7(a) and 7(b) explain a process for forming wiring patterns on one of the surfaces of the wiring board 30. However, it is also possible to simultaneously form such wiring patterns on the other surface of the wiring board 30, although an explanation is omitted.

First, as shown in Fig. 7(a), a pair of molds 68, 68 (in Figs. 7(a) and 7(b) only one of the pair of molds 68, 68 is shown) having projections 72 for forming wiring pattern recesses 16 and projections 70 for forming via recesses 42 is used. This pair of molds 60a and 60b can be made by a known electric-forging method.

Next, the pair of molds 68, 68 are closed to define a cavity 74 into which a wiring board 30 is inserted, so that the tip ends of the projections 72 for forming wiring pattern recesses 16 are come into contact with the pads of the wiring board 30.

Next, a resin 66 is injected into the cavity and solidified so as to form via recesses 42, 42, .. and

wiring pattern recesses 16, 16, .. on the resin layers 40 provided on the respective surfaces of the wiring board 30.

5 In addition, by the same steps as Figs. 5(c) to 5(e), vias 56, 56, .. and wiring patterns 16, 16, .. can be formed.

10 Next, the wiring board 30 having the resin layer 40 provided with the vias 56, 56, .. and wiring patterns 24, 24, .. is inserted into the cavity 74 of the pair of injection molds 68, 68. The steps of injecting a resin 66 into the cavity 74 and hardening or solidifying the resin, and the steps of Figs. 5(a) to 5(e) are repeated to form a multi-layer wiring board.

15 The wiring board 30 shown in Fig. 2 has solder balls 32, 32, .. as external connecting terminals on the other surface thereof. Therefore, during the manufacturing process of the wiring board 30 a step for attaching the solder balls 32, 32, .. is necessary.

20 In this connection, since the wiring board 30 manufactured by the process of Figs. 8(a) to 8(c) is provided beforehand with projected portions for the external connecting terminals, so that a step for attaching solder balls 32, 32, .. is no longer necessary.

25 First, as shown in Fig. 8(a), each of the pair of injection molds 80a and 80b is provided with projections 82 for forming wiring pattern recesses 16 and projections 84 for forming via through holes 18. In addition, the injection mold 80b is provided with recesses 86, 86, .. for forming projections for the external connecting  
30 terminals.

35 A processing resin plate 10 as shown in Fig. 1(a) is inserted into the space between these pair of injection molds 80a and 80b, which is then closed to form a resin plate 12 which is provided with the wiring pattern recesses 16 and the via through holes 18, and also provided with projections 88 for the external connecting terminals at the positions where the external connecting

terminals should be formed.

In addition, electro-plating is applied to all of the surfaces of the resin plate 12 including the inner walls of the wiring pattern recesses 16 and the via through holes 18 and outer wall of the projections 88 for the external connecting terminals using the thin metal film as a power supply layer. Thus, as shown in Fig. 8(b), the inner walls of the wiring pattern recesses 16 and the via through holes 18 are filled with a plated metal to form a metal layer 22. This metal layer is also formed on the surfaces of the resin plate 12 where the wiring pattern recesses 16 and the via through holes 18 are not formed.

Therefore, as shown in Fig. 8(c), the portions of the metal layer 22 attached to outer wall of the projections 88 for the external connecting terminals are removed and electrically disconnected from the vias 26 which are formed by filling the plated metal into the via through holes 18. Thus, a wiring board 30 is formed which has one surface on which vias 26 and the wiring patterns 24 are exposed, opposite to the other surface provided with projections 88 for external connecting terminals. Such a removal of the metal layer 22 can be carried out by polishing the metal layer on one of the surface of the resin plate 12. It is preferable to remove by etching the metal layer on the opposite surface of the resin plate 12 after forming resist patterns, exposure thereof and development thereof.

The wiring board 30 as shown in Fig. 8(c) has the other surface provided with the external connecting terminals 90 covered with metal layers 22 on the outer wall of the projections 88. The external connecting terminals 90 are electrically connected with the vias 26 by means of the wiring patterns 92.

Therefore, when the wiring board 30 shown in Fig. 8(c) is used as a semiconductor package, solder balls 34, 34, .. as connecting terminals are attached to the pads

of the wiring patterns 24 formed on the one surface of the resin plate which are connected to the electrode terminals of the semiconductor element 36 which is to be mounted.

5           Solder resist 38 is attached to the respective surfaces of the resin plate 12 except for the portions corresponding to the solder balls 34, 34, .. attached to the respective pads and the external connecting terminals 90, 90, ..

10           Although the pair of molds 80a and 80b are used to obtain a resin plate 12 having a predetermined shape in the embodiment shown in Figs. 8(a) to 8(c), the pair of molds 80a and 80b can be replaced with a pair of injection molds 80a and 80b between which a cavity is  
15           defined. When these injection molds 80a and 80b are closed, a molten resin is injected into the cavity to obtain a resin plate as shown in Fig. 8(b).

          In the same steps as shown in Fig. 8(b), the inner walls of the wiring pattern recesses 16 and the via  
20           through holes 18 are filled with a plated metal to form a metal layer 22.

          Then, in the same steps as shown in Fig. 8(c), the portions of the metal layer 22 attached to outer wall of the projections 88 for the external connecting terminals  
25           are removed and electrically disconnected from the vias 26 which are formed by filling the plated metal into the via through holes 18. Thus, a wiring board 30 which has one surface on which vias 26 and the wiring patterns 24 are exposed, opposite to the other surface provided with  
30           projections 88 for external connecting terminals can thus be obtained.

          It should be understood by those skilled in the art that the foregoing description relates to only some preferred embodiments of the disclosed invention, and  
35           that various changes and modifications may be made to the invention without departing the sprit and scope thereof.